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## 1 [Profiling Java applications using code hotswapping and dynamic call graph revelation](#)

Mikhail Dmitriev

January 2004 **ACM SIGSOFT Software Engineering Notes , Proceedings of the fourth international workshop on Software and performance**, Volume 29 Issue 1

Full text available:  [pdf\(1.32 MB\)](#)

Additional Information: [full citation](#), [abstract](#), [references](#)

Instrumentation-based profiling has many advantages and one serious disadvantage: usually high performance overhead. This overhead can be substantially reduced if only a small part of the target application (for example, one that has previously been identified as a performance bottleneck) is instrumented, while the rest of the application code continues to run at full speed. The value of such a profiling technology would increase further if the code could be instrumented and de-instrumented as m ...

## 2 [Dynamic hot data stream prefetching for general-purpose programs](#)

Trishul M. Chilimbi, Martin Hirzel

May 2002 **ACM SIGPLAN Notices , Proceedings of the ACM SIGPLAN 2002 Conference on Programming language design and implementation**, Volume 37 Issue 5

Full text available:  [pdf\(210.85 KB\)](#)

Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)


Prefetching data ahead of use has the potential to tolerate the growing processor-memory performance gap by overlapping long latency memory accesses with useful computation. While sophisticated prefetching techniques have been automated for limited domains, such as scientific codes that access dense arrays in loop nests, a similar level of success has eluded general-purpose programs, especially pointer-chasing codes written in languages such as C and C++. We address this problem by describing ...

**Keywords:** data reference profiling, dynamic optimization, dynamic profiling, memory performance optimization, prefetching, temporal profiling

## 3 [Concurrent garbage collection using hardware-assisted profiling](#)

Timothy H. Heil, James E. Smith

October 2000 **ACM SIGPLAN Notices , Proceedings of the 2nd international symposium on Memory management**, Volume 36 Issue 1

Full text available:  [pdf\(1.74 MB\)](#)

Additional Information: [full citation](#), [abstract](#), [citations](#), [index terms](#)

In the presence of on-chip multithreading, a Virtual Machine (VM) implementation can readily take advantage of *service threads* for enhancing performance by performing tasks such as profile collection and analysis, dynamic optimization, and garbage collection concurrently with program execution. In this context, a hardware-assisted profiling mechanism is proposed. The *Relational Profiling Architecture* (RPA) is designed from the top

4 Characterizing the memory behavior of Java workloads: a structured view and opportunities for optimizations

Yefim Shuf, Mauricio J. Serrano, Manish Gupta, Jaswinder Pal Singh

June 2001 **ACM SIGMETRICS Performance Evaluation Review , Proceedings of the 2001 ACM SIGMETRICS international conference on Measurement and modeling of computer systems**, Volume 29 Issue 1

Full text available:  pdf(1.55 MB)

Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#)

This paper studies the memory behavior of important Java workloads used in benchmarking Java Virtual Machines (JVMs), based on instrumentation of both application and library code in a state-of-the-art JVM, and provides structured information about these workloads to help guide systems' design. We begin by characterizing the inherent memory behavior of the benchmarks, such as information on the breakup of heap accesses among different categories and on the hotness of references to fields and met ...

5 Creating and preserving locality of java applications at allocation and garbage collection times

Yefim Shuf, Manish Gupta, Hubertus Franke, Andrew Appel, Jaswinder Pal Singh

November 2002 **ACM SIGPLAN Notices , Proceedings of the 17th ACM SIGPLAN conference on Object-oriented programming, systems, languages, and applications**, Volume 37 Issue 11

Full text available:  pdf(180.20 KB)

Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)

The growing gap between processor and memory speeds is motivating the need for optimization strategies that improve data locality. A major challenge is to devise techniques suitable for pointer-intensive applications. This paper presents two techniques aimed at improving the memory behavior of pointer-intensive applications with dynamic memory allocation, such as those written in Java. First, we present an allocation time object placement technique based on the recently introduced notion of  $p$  ...

**Keywords:** *JVM, Java, garbage collection, heap traversal, locality, locality based graph traversal, memory allocation, memory management, object co-allocation, object placement, prolific types, run-time systems*

6 The Jrpm system for dynamically parallelizing Java programs

Michael K. Chen, Kunle Olukotun

May 2003 **ACM SIGARCH Computer Architecture News , Proceedings of the 30th annual international symposium on Computer architecture**, Volume 31 Issue 2

Full text available:  pdf(320.42 KB)

Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#)

We describe the Java runtime parallelizing machine (Jrpm), a complete system for parallelizing sequential programs automatically. Jrpm is based on a chip multiprocessor (CMP) with thread-level speculation (TLS) support. CMPs have low sharing and communication costs relative to traditional multiprocessors, and thread-level speculation (TLS) simplifies program parallelization by allowing us to parallelize optimistically without violating correct sequential program behavior. Using a Java virtual ma ...

7 A framework for reducing the cost of instrumented code

Matthew Arnold, Barbara G. Ryder

May 2001 **ACM SIGPLAN Notices , Proceedings of the ACM SIGPLAN 2001 conference on Programming language design and implementation**, Volume 36 Issue 5

Full text available:  pdf(1.78 MB)

Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)

Instrumenting code to collect profiling information can cause substantial execution overhead. This overhead makes instrumentation difficult to perform at runtime, often

preventing many known *offline* feedback-directed optimizations from being used in online systems. This paper presents a general framework for performing *instrumentation sampling* to reduce the overhead of previously expensive instrumentation. The framework is simple and effective, using code-duplication and *count* ...

8 Continuous program optimization: A case study

Thomas Kistler, Michael Franz

July 2003 **ACM Transactions on Programming Languages and Systems (TOPLAS)**,  
Volume 25 Issue 4

Full text available:  pdf(877.67 KB)

Additional Information: [full citation](#), [abstract](#), [references](#), [index terms](#),  
[review](#)

Much of the software in everyday operation is not making optimal use of the hardware on which it actually runs. Among the reasons for this discrepancy are hardware/software mismatches, modularization overheads introduced by software engineering considerations, and the inability of systems to adapt to users' behaviors. A solution to these problems is to delay code generation until load time. This is the earliest point at which a piece of software can be fine-tuned to the actual capabilities of the ...

**Keywords:** Dynamic code generation, continuous program optimization, dynamic reoptimization

9 Practicing JUDO: Java under dynamic optimizations

Michał Cierniak, Guei-Yuan Lueh, James M. Stichnoth

May 2000 **ACM SIGPLAN Notices , Proceedings of the ACM SIGPLAN 2000 conference on Programming language design and implementation**, Volume 35 Issue 5

Full text available:  pdf(190.06 KB)

Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)

A high-performance implementation of a Java Virtual Machine (JVM) consists of efficient implementation of Just-In-Time (JIT) compilation, exception handling, synchronization mechanism, and garbage collection (GC). These components are tightly coupled to achieve high performance. In this paper, we present some static and dynamic techniques implemented in the JIT compilation and exception handling of the Microprocessor Research Lab Virtual Machine (MRL VM), ...

10 Online feedback-directed optimization of Java

Matthew Arnold, Michael Hind, Barbara G. Ryder

November 2002 **ACM SIGPLAN Notices , Proceedings of the 17th ACM SIGPLAN conference on Object-oriented programming, systems, languages, and applications**, Volume 37 Issue 11

Full text available:  pdf(463.00 KB)

Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)

This paper describes the implementation of an online feedback-directed optimization system. The system is fully automatic; it requires no prior (offline) profiling run. It uses a previously developed low-overhead instrumentation sampling framework to collect control flow graph edge profiles. This profile information is used to drive several traditional optimizations, as well as a novel algorithm for performing feedback-directed control flow graph node splitting. We empirically evaluate this system ...

**Keywords:** adaptive optimization, dynamic optimization, online algorithms, virtual machines

11 Improving Java performance using hardware translation

Ramesh Radhakrishnan, Ravi Bhargava, Lizy K. John

June 2001 **Proceedings of the 15th international conference on Supercomputing**

Full text available:  pdf(254.91 KB)

Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)

State of the art Java Virtual Machines with Just-In-Time (JIT) compilers make use of advanced compiler techniques, run-time profiling and adaptive compilation to improve performance. However, these techniques for alleviating performance bottlenecks are more effective in long running workloads, such as server applications. Short running Java programs, or client workloads, spend a large fraction of their execution time in compilation instead of useful execution when run using JIT compilers. In ...

## 12 The Performance of Runtime Data Cache Prefetching in a Dynamic Optimization System

Jiwei Lu, Howard Chen, Rao Fu, Wei-Chung Hsu, Bobbie Othmer, Pen-Chung Yew, Dong-Yuan Chen

December 2003 **Proceedings of the 36th Annual IEEE/ACM International Symposium on Microarchitecture**


Full text available:  pdf(253.79 KB) Additional Information: [full citation](#), [abstract](#), [citations](#), [index terms](#)

Traditional software controlled data cache prefetching is often ineffective due to the lack of runtime cache miss and miss address information. To overcome this limitation, we implement runtime data cache prefetching in the dynamic optimization system ADORE (ADaptive Object code RE-optimization). Its performance has been compared with static software prefetching on the SPEC2000 benchmark suite. Runtime cache prefetching shows better performance. On an Itanium 2 based Linux workstation, it can increase speed ...

## 13 Dynamic metrics for java

Bruno Dufour, Karel Driesen, Laurie Hendren, Clark Verbrugge

October 2003 **ACM SIGPLAN Notices , Proceedings of the 18th annual ACM SIGPLAN conference on Object-oriented programming, systems, languages, and applications**, Volume 38 Issue 11

Full text available:  pdf(222.67 KB) Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)

In order to perform meaningful experiments in optimizing compilation and run-time system design, researchers usually rely on a suite of benchmark programs of interest to the optimization technique under consideration. Programs are described as *numeric*, *memory-intensive*, *concurrent*, or *object-oriented*, based on a qualitative appraisal, in some cases with little justification. We believe it is beneficial to quantify the behaviour of programs with a concise and precise ...

**Keywords:** Java, dynamic metrics, execution traces, optimization, profiling, program analysis, software metrics

## 14 A brief history of just-in-time

John Aycock

June 2003 **ACM Computing Surveys (CSUR)**, Volume 35 Issue 2


Full text available:  pdf(171.09 KB) Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)

Software systems have been using "just-in-time" compilation (JIT) techniques since the 1960s. Broadly, JIT compilation includes any translation performed dynamically, after a program has started execution. We examine the motivation behind JIT compilation and constraints imposed on JIT compilation systems, and present a classification scheme for such systems. This classification emerges as we survey forty years of JIT work, from 1960--2000.

**Keywords:** Just-in-time compilation, dynamic compilation

## 15

SAFKASI: a security mechanism for language-based systems

Full text available:  [pdf\(234.89 KB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [citations](#), [index terms](#)

In order to run untrusted code in the same process as trusted code, there must be a mechanism to allow dangerous calls to determine if their caller is authorized to exercise the privilege of using the dangerous routine. Java systems have adopted a technique called stack inspection to address this concern. But its original definition, in terms of searching stack frames, had an unclear relationship to the actual achievement of security, overconstrained the implementation of a Java system, lim ...

**Keywords:** Internet, Java, WWW, access control, applets, security-passing style, stack inspection

16 Research papers III: Comparative performance analysis of mobile runtimes on Intel XScale® technology

Jason Damer, Murthi Nanja, Suresh Srinivas, Bhaktha Keshavachar

June 2004 **Proceedings of the 2004 workshop on Interpreters, virtual machines and emulators**

Full text available:  [pdf\(226.94 KB\)](#) Additional Information: [full citation](#), [abstract](#), [references](#), [index terms](#)

Mobile Runtime Environments such as Java\*2 Micro Edition (J2ME\*) and Microsoft WinCE.NET\* Compact Framework\* are becoming standard managed application execution environments on memory constrained devices. A variety of implementations exists, and so too are a variety of systems they could run on, and finally a variety of workloads. It becomes important to understand how they compare. In this paper we describe comparative performance analysis of mobile runtimes on products with Intel XScale® mi ...

17 Hardware Support for Control Transfers in Code Caches

Ho-Seop Kim, James E. Smith

December 2003 **Proceedings of the 36th Annual IEEE/ACM International Symposium on Microarchitecture**

Full text available:  [pdf\(315.74 KB\)](#) Additional Information: [full citation](#), [abstract](#), [index terms](#)

Many dynamic optimization and/or binary translation systems hold optimized/translated superblocks in a code cache. Conventional code caching systems suffer from overheads when control is transferred from one cached superblock to another, especially via register-indirect jumps. The basic problem is that instruction addresses in the code cache are different from those in the original program binary. Therefore, performance for register-indirect jumps depends on the ability to translate efficiently from source ...

18 Reducing virtual call overheads in a Java VM just-in-time compiler

Junpyo Lee, Byung-Sun Yang, Suhyun Kim, Kemal Ebcioglu, Erik Altman, Seungil Lee, Yoo C. Chung, Heungbok Lee, Je Hyung Lee, Soo-Mook Moon

March 2000 **ACM SIGARCH Computer Architecture News**, Volume 28 Issue 1

Full text available:  [pdf\(994.66 KB\)](#) Additional Information: [full citation](#), [abstract](#), [index terms](#)

Java, an object-oriented language, uses *virtual methods* to support the extension and reuse of classes. Unfortunately, virtual method calls affect performance and thus require an efficient implementation, especially when just-in-time (JIT) compilation is done. *Inline caches* and *type feedback* are solutions used by compilers for dynamically-typed object-oriented languages such as SELF [1, 2, 3], where virtual call overheads are much more critical to performance than in Java. We ...

**Keywords:** Java JIT compilation, adaptive compilation, inline cache, type feedback, virtual method call

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Welcome to the Opportunities of Binary Translation - Altman, al. (2000) (Correct) (5 citations)  
Static translators can also use execution **profiles** obtained during a program's previous run. All can be ported to any platform for which a Java **virtual machine** (VM) is available. One approach to with that of commercial Java VMs, such as Sun's **HotSpot** and JDK 1.2. Latte is a research prototype and [www.eecs.harvard.edu/cs253/papers/r3040.pdf](http://www.eecs.harvard.edu/cs253/papers/r3040.pdf)

Online Feedback-Directed Optimization of Java - Matthew Arnold Michael (2002) (Correct) (2 citations)  
framework to collect control flow graph edge **profiles**. This **profile** information is used to drive [www.research.rutgers.edu/~marnold/papers/oopsla02.ps](http://www.research.rutgers.edu/~marnold/papers/oopsla02.ps)

Application of the HotSwap Technology to Advanced Profiling - Dmitriev (2002) (Correct) (2 citations)  
bytecode instrumentation would allow developers to **profile** dynamically selected parts of the target implemented in the Sun's Java **HotSpot** **Virtual Machine**. This functionality was initially considered has been recently implemented in the Sun's Java **HotSpot** **Virtual Machine**. This functionality was [www.dcs.gla.ac.uk/~misha/papers/hsprof.ps.gz](http://www.dcs.gla.ac.uk/~misha/papers/hsprof.ps.gz)

The Case for Multiple Compilers - Detlefs, Agesen (1999) (Correct) (2 citations)  
different characteristics: some have very "steep" **profiles**, with almost all execution time spent in a Presented at OOPSLA '99 **Virtual Machine Workshop** The Case for Multiple Compilers More aggressive Sun, Sun Microsystems, Java, **HotSpot**, Solaris, and Ultra are trademarks or [wwwswest.sun.com/research/people/detlefs/papers/99-oopsla-3tier.ps](http://wwwswest.sun.com/research/people/detlefs/papers/99-oopsla-3tier.ps)

Design, Implementation and Evaluation of Adaptive Recompilation .. - Fink, Qian (2003) (Correct) (1 citation)  
including a study of fully automatic, online, **profile**-driven deferred compilation. 1 Introduction [fqian@sable.mcgill.ca](mailto:fqian@sable.mcgill.ca) Abstract Modern **virtual machines** often maintain multiple compiled versions of VMs, with the notable exception of Sun's **HotSpot** Server Compiler [12] due to the perceived [www.research.ibm.com/people/s/fink/papers/cgo03.ps.gz](http://www.research.ibm.com/people/s/fink/papers/cgo03.ps.gz)

Measurement and Analysis of - Runtime Profiling Data (Correct)  
To examine the effect of compiler choice on such **profiles**, since this should be known when gathering test suites and compilers. Keywords Java **Virtual Machine**, Bytecode Analysis, Contingency Measure 1. optimisations such as Just-In-Time (JIT) [8] and **hotspot**-based [2] compilation, as well as comparative [www.cs.ucsb.edu/~ckrintz/papers/javaprof-scam01.pdf.gz](http://www.cs.ucsb.edu/~ckrintz/papers/javaprof-scam01.pdf.gz)

WS 9. The First International Workshop on - Unanticipated Software Evolution (2002) (Correct)  
bytecode instrumentation allows developers to **profile** dynamically selected parts of a target supported by Sun Microsystems' Java **HotSpot Virtual Machine**: Pazandak [21] presents ProbeMeister, a in JDK 1.4 and supported by Sun Microsystems' Java **HotSpot Virtual Machine**: Pazandak [21] presents [www.informatik.uni-bonn.de/~gk/papers/ecoop2002/ecoopWsReportUSE2002.pdf](http://www.informatik.uni-bonn.de/~gk/papers/ecoop2002/ecoopWsReportUSE2002.pdf)

Cache Performance in Java Virtual Machines: A Study of.. - Rajan, Rubio, John (2002) (Correct)  
the mixed mode execution engine [19] which uses **profile** based feedback to interpret/compile bytecodes. 1 Cache Performance in Java **Virtual Machines**: A Study of Constituent Phases Anand S. has been shown to be comparable to Sun's JDK 1.3 (**HotSpot**) VM. Latte boasts of a highly optimized JIT [www.ece.utexas.edu/projects/ece/lca/ps/anand.pdf](http://www.ece.utexas.edu/projects/ece/lca/ps/anand.pdf)

Improving Branch Predictability in Java Processing - Li, John, Narayanan (2001) (Correct)  
a complete system simulation environment, we **profile**, analyze and quantify performance issues of format known as bytecodes and a Java **Virtual Machine** (JVM) [Lind99] dedicated to a specific in state-of-the-art JVM technologies such as Sun's **HotSpot** [HotSpot99] The execution of Java applications [www.ece.utexas.edu/projects/ece/lca/ps/tao-TR-february-2001.pdf](http://www.ece.utexas.edu/projects/ece/lca/ps/tao-TR-february-2001.pdf)

Platform Independent Dynamic Java Virtual Machine Analysis.. - Gregg, Power, al. (2001) (Correct)  
a platform independent analysis of the dynamic **profiles** of Java programs when executing on the Java Platform Independent Dynamic Java **Virtual Machine** Analysis: the Java Grande Forum Benchmark such as Just-In-Time (JIT) e.g. [1, 8] and **hotspot**-centered compilation (see [9] for a survey) The

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Measurement and Analysis of Runtime Profiling Data for.. - Horgan, Power, Waldron (2001) (Correct)  
does not provide full information on the dynamic **profile** of the program. For large programs the dynamic by the execution of the code on the Java **Virtual Machine (JVM)** The problem addressed by this yielding techniques such as Just-In-Time (JIT) and **hotspot**-centered compilation [2] However, the [www.cs.may.ie/~pgibson/TRseries/nuim-cs-tr-2001-04.pdf](http://www.cs.may.ie/~pgibson/TRseries/nuim-cs-tr-2001-04.pdf)

Hardware Support for Profiling Java Programs - Hanish, Cohen (Correct)  
The JIT system generates in-line machine code to **profile** each method. In the prologue of the method, the system has been developed for the Kaffe Java **Virtual Machine's (JVM)** Just-In-Time (JIT) i386 translator code as proposed by Hlzle [3] and implemented in **HotSpot** [6] This profiling information is essential [www.eb.uah.edu/~cohen/javanauts/papers/iccd99b.ps](http://www.eb.uah.edu/~cohen/javanauts/papers/iccd99b.ps)

Efficient Parallel Execution of Irregular Recursive Programs - Prechelt, Hänßgen (1999) (Correct)  
code even for irregular problems whose parallelism **profile** is highly data-dependent and can hence not be on profiling are used by Sun's **Hotspot Java Virtual Machine 1** With respect to the goals of REAPAR, optimizations based on profiling are used by Sun's **Hotspot Java Virtual Machine 1** With respect to the [www.wipd.ira.uka.de/~prechelt/Biblio/reapar\\_tps1999.ps.gz](http://www.wipd.ira.uka.de/~prechelt/Biblio/reapar_tps1999.ps.gz)

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3. [Modularity, Hardware Profiling, and Mixed ISA Execution in Managed Runtimes \(PDF\)](#)

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4. [Instruction-Set Simulation and Tracing](#)

Instruction-Level Simulation And Tracing. This is \$Revision: 1.107 \$, last updated \$Date: 2004/06/08 17:36:44 \$. For an up-to-date version, please check [www.xsim.com/bib](http://www.xsim.com/bib).  
[www.xsim.com/bib/index1.d/Index.html](http://www.xsim.com/bib/index1.d/Index.html) - 318k - [Cached](#) - [More from this site](#)

5. [-CHAPTER](#)


Performance Analyzer. C H A P T E R 5. Understanding the Performance Analyzer and Its Data. The Performance Analyzer reads the event data that is collected by the Collector and converts it into performance metrics. ... data files representing the **profile** events in the life ... by the Java **HotSpot virtual machine**, and are referred ... handling, memory management, and Java **HotSpot virtual machine** compilation ...  
[docs.sun.com/source/817-5068/AdvancedTopics.html](http://docs.sun.com/source/817-5068/AdvancedTopics.html) - 143k - [Cached](#) - [More from this site](#)

6. [7 - CHAPTER -](#)

... a small number of **profile** packets is recorded, the call ... compiled by the Java **HotSpot virtual machine**, and there is ... such as at a **cache miss** or a resource queue ...  
[docs.sun.com/source/816-2458/AdvancedTopics.html](http://docs.sun.com/source/816-2458/AdvancedTopics.html) - 106k - [Cached](#) - [More from this site](#)

7. [Digital Mars - D - Java vs C Benchmarks](#)

... Java virtual machines do some amazing things: they **profile** the ... The people working on **hotspot** in particular have hinted that Java ... Actually, the **virtual machine** has great overhead ...  
[www.digitalmars.com/d/archives/13897.html](http://www.digitalmars.com/d/archives/13897.html) - 93k - [Cached](#) - [More from this site](#)

8. [Java Technology and XML-Part 3: Performance Improvement Tips](#)   
... Network Community. **Profile** and Registration | Why Register? ... TRACE)  
{ System.err.println("Query cache miss (mismatch)."); ... Asked Questions about  
the Java **HotSpot Virtual Machine** ...  
jdl.sun.com/developer/technicalArticles/xml/JavaTechandXML\_part3 - 77k -  
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